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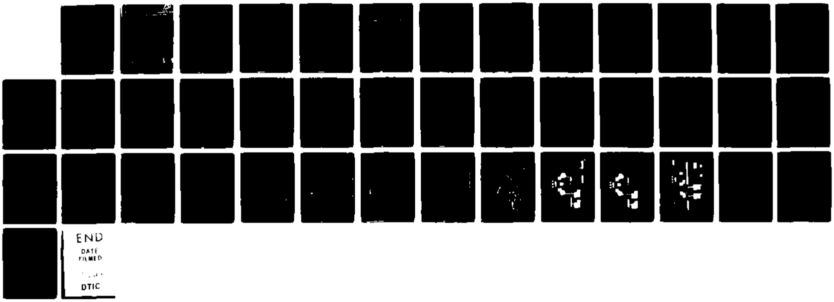

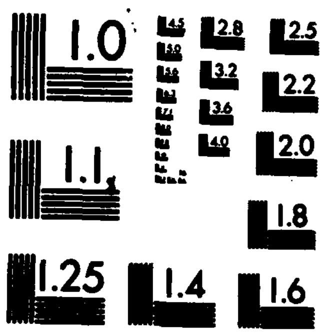

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Advanced Automation
Program Office
Washington, D.C. 20591

Advanced Automation System (AAS) Transition Strategy

April 1983

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16. Abstract

The Advanced Automation System comprises all of the automation equipment required for Air Traffic Control at the Area Control Facilities and Air Traffic Control Towers to accommodate the ATC evolution of the 1990 - 2010 era.

This report describes the strategy and supporting rationale for transitioning from today's automation system to the Advanced Automation System. The approach presented here forms the basis for much of the Advanced Automation Program planning and is reflected in the detailed transition, facility modernization, test, training, and budget planning.

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METRIC CONVERSION FACTORS

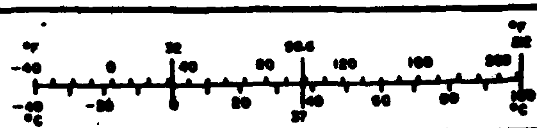
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



60 mph = 52.1 knots (nautical miles per hour)
60 mph = 88'/sec   1g = 32.2'sec^2

1 mph = .87 knots
1 knot - 1.15 mph

FOREWORD

This document describes the approved transition strategy for the Advanced Automation System (AAS) and provides information and guidance to individuals and organizations involved in the planning, development and implementation of the AAS.

APPROVED: [signature] DATE: Apr. 29, 1983

Director
Advanced Automation Program Office, AAP-1

PREFACE

This report presents FAA's strategy for automation system transition from today's en route and terminal facilities to an Advanced Automation System (AAS) at 23 Area Control Facilities (ACF) and some 300 Air Traffic Control Towers (ATCTs).

The report is organized into three chapters:

Chapter 1 serves as an introduction. It defines the scope of the Advanced Automation Program and relates it to the National Airspace System Plan; it defines AAS transition requirements and precepts; and finally, it provides an overview of the transition steps at the 20 continental U.S. (CONUS) Air Route Traffic Control Centers (ARTCCs) and of the operational transition from an en route/terminal system to a system of 23 ACFs, each with a common automation system, called an Area Control Computer Complex (ACCC), and approximately 300 Air Traffic Control Towers, each with a Tower Control Computer Complex (TCCC).

Chapter 2 presents a detailed discussion of each of the four transition steps. Transition will begin at the CONUS ARTCCs much earlier than for the ACCC at the three other ACFs (Anchorage, Honolulu, and New York TRACON), or for the TCCC at towers. Correspondingly, more planning has been done for the CONUS ARTCCs transition and therefore, more detail is provided for the three steps at the CONUS ARTCCs transition.

Chapter 3 presents a short summary of the transition.

The report is intended to convey to the reader FAA's approach to transition and the rationale for the selection of this particular approach. The report will provide the foundation for the development of a hierarchy of transition documents. These consist of FAA Implementation Plans for Host System, Initial Sector Suite System, and Advanced Automation System. Lower level, design dependent transition planning documents are expected to be developed by the Host and AAS prime contractors.

This report also addresses broad training requirements associated with the different transition steps. A more detailed plan for training will be provided by FAA in the Advanced Automation Program Integrated Logistics Support (ILS) Plan.

Finally, the Advanced Automation Program Office technical, management, and acquisition approaches will be delineated in a Program Master Plan, Program Management Plan, and a Technical Development Plan.

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TRANSITION TO THE ADVANCED AUTOMATION SYSTEM

1.0 INTRODUCTION

1.1 Objectives

The National Airspace System (NAS) Plan (December 1981) has outlined an ambitious approach to the modernization of the National Airspace System. The development and implementation of the Advanced Automation System (AAS) to support en route and terminal air traffic control is an integral part of the NAS Plan. This report lays out an approach, with rationale, to the transition from today's en route and terminal automation systems to an Area Control Computer Complex (ACCC) at 23 Area Control Facilities (ACFs). The approach presented here has been approved and forms the basis for much of the Advanced Automation Program planning. It is reflected in the procurement packages for Host and AAS systems, in the detailed transition, facility modernization, test, training, and budget planning by the Advanced Automation Program Office (AAPO), and in the definition of relationships with other programs and interfaces with other systems that form part of the NAS Plan.

1.2 Background

The present air traffic control system is comprised of FAA ground facilities that provide en route and terminal air traffic control services. Aircraft flying en route between terminal areas and operating under instrument flight rules are controlled by air route traffic control centers (ARTCCs). There are 20 ARTCCs in the Continental United States (CONUS) and three offshore centers. In terminal areas, there are about 400 airport traffic control towers (ATCTs) each of which is located on the surface of the airport it serves. Almost 200 of these ATCTs are served by terminal radar approach control (TRACON/TRACAB) facilities that provide air traffic control services to aircraft arriving at and departing from the airport being served. Normally each TRACON is associated with one ATCT and located within the same building. However, a TRACON may be remotely located and serve more than one ATCT. A TRACAB is located within the ATCT cab at an airport with a low-traffic density.

The National Airspace System Plan calls for an evolution in en route and terminal air traffic control systems from the present until the year 2000 and beyond in two related areas -- new and improved automation support and consolidation of existing facilities. The AAS shall directly support both of these related efforts by:

1. Providing an integrated computing system as a basis for consolidation of operations,

2. Replacing existing, aging automation equipment,

3. Adding new automation capabilities, and

4. Allowing the use of common equipment to perform similar functions.

During this evolution the existing ARTCCs and TRACON/TRACAB facilities will be consolidated to form Area Control Facilities (ACF). All en route and approach/departure control will be accomplished from 23 ACFs. The Area Control Computer Complex (ACCC) at the ACFs will be tied, via a telecommunication network, to Tower Control Computer Complexes (TCCCs) at some 300 Air Traffic Control Towers (ATCT). It is planned that the 20 Conus ARTCCs, the NY TRACON, Anchorage ARTCC, and Honolulu ARTCC will make up the 23 ACFs.

1.3 Program Scope

The Advanced Automation Program (AAP) will provide all the automation equipment and software required for air traffic control at the ACFs and at the ATCTs and the support equipment required, primarily at the FAA Technical Center (FAATC), to test and maintain the software and hardware for the systems at the operational sites. Site preparation/construction, training, logistics, and field support will also be part of the AAP.

The Advanced Automation Program includes responsibility for the transition from today's automation and support systems to the Advanced Automation Systems and for any development and implementation activity required by this transition.

The Advanced Automation System will provide an overall design that can accommodate the ATC evolution of the 1990-2010 era. When initially installed, the system will have the capability to perform today's functions, a number of near term enhancements (conflict alert for VFR intruders, conflict resolution advisories and improved en route metering), and AERA I - the initial elements (direct route planning and improved flow management) of the Automated En Route ATC (AERA) system. The AAS will be capable of supporting en route and terminal ATC in a single system. It will have a greatly improved man/machine interface, including a totally new controller work station (sector suite) for greater productivity. The AAS is characterized by increased availability and reliability, lower cost maintenance, and flexibility for technology upgrading. Its evolutionary design will accommodate traffic growth, changes in the ATC environment, new functions (e.g., AERA), and new data sources (surveillance systems, navigation systems, communication systems) described in the NAS Plan.

The AAS, when fully installed in the early to mid 1990's, will contain five major elements: an Area Control Computer Complex (ACCC) at each ACF; a Tower Control Computer Complex (TCCC) at each of 300 ATCT; a System Support Computer Complex (SSCC) at the FAATC; a Research and Development Computer Complex (RDCC) at the FAATC; and an Advanced Automation Training System with elements at each of the above facilities and at the FAA Academy.

The ACCC will consist of a newly designed distributed computer hardware and software system; a Local Communication Network (LCN) to handle the non-voice communication within the ACCC, between the ACCC and other systems at an ACF (Flight Service Data Processing System, Center Weather Processor, and Maintenance Processing System), and the intrafacility communication between these other ACF systems; and a newly designed

sector suite that incorporates new input and output devices, including a display for electronic presentation of flight data information (to replace the existing printed flight strips). The TCCC will contain: new TCCC position consoles; any local computer hardware and software required by the AAS design; and interfaces to airport sensor systems, including the applicable terminal surveillance system(s). System Support at the FAATC will be provided by a System Support Computer Complex (SSCC) which contains the hardware and software for: replicating any ACCC and TCCC; replicating two ACCCs simultaneously; reconfiguration of the equipment into the above systems; and hardware and software to support all system maintenance activities. Finally, there will be, at the FAATC, a Research and Development Computer Complex (RDCC) that contains all elements of an ACCC (including six sector suites) and a TCCC.

1.4 Transition Requirements

Three characteristics of the ATC Automation System drive the transition strategy. First, and most important, Air Traffic Control is a 24 hour a day, seven days a week operation that cannot be interrupted as new automation hardware and software are introduced.

Second, the introduction of new system elements cannot in any way jeopardize the safety of air traffic operations. This means that installation should not disrupt ongoing ATC operations. During the initial period of operation, care must be taken that equipment failures are minimized and that adequate backup equipment is available should failures occur. It also means that new methods of operation and new controller input/output techniques must be introduced in a manner that minimizes the potential for human error. Adequate training and limiting the number of different man/machine configurations during the transition will help in this respect.

The third characteristic of the ATC automation system that has important transition considerations is its size (on the order of one million lines of code) and the fact that it is a single, integrated system. Experience with other large systems has shown that the transition must be approached in several manageable steps rather than in one single step. Generally this is achieved by upgrading or replacing a system a few functions at a time. Unfortunately, the existing ATC software is not capable of being functionally partitioned and therefore, does not lend itself to such a transition strategy.

1.5 Transition Precepts

The selection of the transition strategy that has been adopted for the AAS by FAA has been guided by a number of precepts. These are:

1. Capacity improvements to the en route ATC automation system will be needed in the 1986/87 timeframe. Analysis has shown that en route software cannot be replaced in time to meet this need.

2. The transition approach should provide increases in controller productivity at the earliest possible time.

3. An AAS design for a system architecture that has a 20-30 year life is a primary objective of the Advanced Automation Program. This objective should not be jeopardized by the transition approach.

4. AAS transition shall not be dependent on the completion of any other elements of the NAS Plan except for the new Voice Switching and Control System (VSCS). VSCS must be installed with (or prior to) implementation of new sector suites.

5. To minimize operational disruption, the transition approach shall minimize the total duration of the equipment installation and checkout period for any transition step at a single facility.

6. There shall be, at a minimum, a two year stabilization period between the transition steps.

7. The basic transition strategy for each transition step is to switch all operations from the old to the new system at the same time in any one facility. Thus, for example, when new sector suites are installed in an ARTCC, Air Traffic Control operation at that center will be done either using all new sector suites or all old PVD/flight strip printer equipment. There will never be an operational system in a single facility that uses some old and some new sector suites.

8. To permit full operational checkout and carefully stage operational introduction of the system installed at each transition step, it shall be possible, for a limited period, to fully operate the facility with either the new system or with the system that was operational prior to this transition step.

9. It shall be possible to simultaneously perform full ATC operations with the old system and perform initial checkout and controller training with the "new" system at each step of the transition.

10. While transition to the ultimate system described in the NAS Plan will be carried out in multiple steps over an extended period, all construction/site preparation necessary at any given facility shall be carried out in a single building program, where practical.

1.6 Backup Philosophy

At every step of the transition a new system configuration is made operational which will have all the requisite redundancy and backup modes built into it. Because of the serious concern with providing automation support to controllers at all times, these "normal" back-up mechanisms will not be adequate during the initial period when a new system configuration is first put into operation. During this initial period additional backup mechanisms, consistent with the general transition backup philosophy outlined below, will be made available. These additional backup mechanisms will remain in place until the new system is perceived to be sufficiently stable by the users (i.e. the Air Traffic Service).

The general transition backup philosophy requires, at each step in the transition, the availability of DARC and the availability of the old system configuration. For example, when a new computer (Host) is

installed to replace the 9020 Computer it must be possible to configure an operational system based on the Host and, at other times, to configure a system based on the 9020 Computer. The following backup process will be followed:

- If the new system fails, controllers will continue operations with DARC. Attempts will be made to restart the new system.

- If the new system cannot be restarted within an operationally acceptable time period, the old system will be started up from a dormant state. During startup, the old system will generate the active (flight and surveillance) data bases because data generated by the failed new system cannot be trusted.

- Operation will continue with the old system until the new system is once again judged to be operationally satisfactory.

Locally developed operational procedures will address conversion to manual flight data processing.

DARC will remain in place after the old system is removed at each transition step except the last. Because DARC plays such an important role in providing ATC service continuity during the transition, the functional capabilities, including the sector by sector switchover provided by Enhanced DARC, are required.

1.7 Transition Steps - Overview

The transition strategy selected for the AAS is built around a step-wise transition of the en route automation system at the 20 Continental U.S. (CONUS) ARTCCs.

This entails three discrete steps (Figure 1). First, the 9020A and D central computer hardware will be replaced by a new, instruction compatible, Host computer. In this configuration, called the Host System, existing software will be retained. Next, a new controller work station (sector suite) will be introduced. This automation system configuration, called the Initial Sector Suite System (ISSS), will provide a new radar situation display as well as electronic tabular display and electronic manipulation of flight progress information. The major portion of the ATC data processing of the ISSS will be done by 9020 software in the Host computer. Some new computer hardware and software as well as a subset of the ACCC Local Communication Network (LCN) will be required for the ISSS.

In the third step, the full ACCC will be implemented at the en route centers by augmenting the ISSS computer hardware, installation of the remainder of the LCN, and installation of the complete ACCC software. During this period ACCC equipment will also be introduced at the remaining three ACFs (Anchorage, Honolulu, and the New York Tracon).

After the ACCC at the 20 CONUS en route centers (by then called ACFs) becomes stable, the gradual operational consolidation of terminal radar sectors into the ACCC can begin. When the approach and departure control for an airport is transferred to an ACCC, a Tower Control Computer Complex (TCCC) will be installed and become operational at that airport.

This approach to transition decomposes the implementation of a large new system, the AAS, into four manageable steps and thereby offers a significant reduction in Advanced Automation Program technical, cost, and schedule risk. The particular steps selected for the transition also fulfill a number of other important requirements:

1. The Host System will provide the capacity relief required at some of the en route centers in the mid to late 1980's and the ability to support some near term functional improvements.

2. The ISSS will, through an improved man/machine interface, particularly the automation of flight data presentation, entry, and manipulation, reduce controller staffing needs (productivity improvement). While the full ACCC will also satisfy the capacity demands and productivity requirements of the ATC system, it could not provide the benefits as early as the Host System or even ISSS as its development schedule is constrained by the time required to design, develop, and fully test new ATC software.

3. The ACCC will provide automation functions for more fuel efficient flight (AERA I) and will serve as the building block for the ATC evolution of the 1990-2010 era.

4. Finally, the incorporation of terminal control into a single Advanced Control Computer Complex and the accompanying introduction of TCCCs brings with it new operational efficiency in terminal hubs, the potential for increases in terminal automation, and the operational and maintenance benefits of facility consolidation.

2.0 TRANSITION

2.1 Introduction

This chapter will provide a detailed description of the three transition steps at the 20 en route facilities and of the operational transition to 23 fully consolidated ACFs and some 300 ATCTs. The discussions will focus on: a description of the system implemented; the fall-back mechanism employed when a system is first installed; facility requirements and impact; staffing impact; unique operational characteristics of the system configuration; training requirements; support facility requirements; and overall impact on the Advanced Automation Program.

2.1.1 Generalized Transition Configurations

While the configuration of the system at each transition step can be described in a general way, only the configuration for the Host System is known in a detailed way at this time. The FAA has specified a general computer system configuration for the Host System. In addition, the FAA has identified precisely what 9020 equipment is to be replaced and how the Host is to be embedded in the en route system. These specifications were based on extensive FAA Host feasibility and risk analysis. In the case of the AAS, FAA has chosen to specify only functional and performance requirements and to give the responsibility for AAS system design to the AAS prime contractors. A distributed system architecture, built around a local communications network, will inherently provide high availability and protection from total system failure. Details of the configuration to be installed, the extent of equipment to be replaced, and the means of interfacing to existing equipment at the second and third step in the transition will be the responsibility of the prime contractors.

2.1.2 Representative Transition Diagrams

A series of "wiring" diagrams will be used in the following sections for ease of exposition of the technical aspects of transition. Because it is impossible to draw such diagrams in an absolutely generic and design independent manner, the diagrams that are used in the ISSS and ACCC sections show specific connectivities. For example, ISSS, in these diagrams, does not replace the display channel but, in point of fact, the decision to replace or not replace the display channel will be based on prime contractor designs and recommendations. Thus these diagrams, except for Host transition, should not be considered literally, either as a requirement or a preferred FAA approach. The text in these sections will clearly identify what the FAA requirements are and where the contractor has design and interface definition freedom. For each step two illustrative diagrams will be used, one to show the initial configuration with a fallback system and one to show the system after removal of the fallback system.

2.1.3 Transition States

To simplify the discussion, four states of the system are defined as follows:

State 0 - Today's System
State 1 - Host System
State 2 - ISSS
State 3 - ACCC

The initial configuration at each transition step, when a fallback system is still in place, will be denoted as Step 0/1, Step 1/2, etc. The starting point for the transition discussion is today's system, State 0 (See Figure 2). The system consists of the 9020 Central Computer Complex (denoted as 9020A or 9020D) which is a multiprocessor made up of specially modified IBM 360 computers; associated standard peripherals; a Peripheral Adapter Module (PAM) that serves as the communications gateway for other facilities, surveillance inputs, and flight strip printers in the control room; a Display Channel that sets up the displays for individual Plan View Displays (PVDs) and contains both the refresh memory for all displays and the Radar Keyboard Multiplexor (RKM); a set of Display Generators (DG), each of which drives six PVDs; and the Direct Access Radar Channel (DARC) which provides a backup radar presentation and ties directly into the display generators.

2.2 Host Transition

The Host transition is the first step (Step 0/1) in a series of three transition steps that will transform today's ATC computer system into the ACCCs. The purpose of this transition is to replace the 9020 computer systems with IBM 360/370 instruction compatible computer systems and to provide additional processing capacity consistent with the growing demand for ATC services.

2.2.1 System Definition

The Host computer system is a current generation IBM 360/370 instruction compatible replacement for the 9020 Computer. Where the 9020 Computer required several processors to handle the en route ATC load, today's technology permits a single, medium-sized computer to handle the entire load. High availability in the 9020 Computer was provided by redundant elements in the multiprocessor configuration; in the Host this will be provided by a second standby computer connected through new standard peripherals. The Host will execute 9020 software adapted to operate on a current generation off-the-shelf computer. The Host will be tied into the existing system through the PAM (standard IBM 360/370 multiplexor channel interface) and the display channel (standard IBM 360/370 selector channel interface). Off-the-shelf channel switches will be provided to permit system operation with either the Host or with the 9020 Central Computer Complex. These and the 9020 CCC will be removed after the Host has demonstrated a satisfactory level of stability during operational use. Figures 3 and 4 show the Host configuration with the 9020 Computer in place and after 9020 Computer removal.

2.2.2 Backup Mechanism

During the Host stabilization period, Host failure will lead to ATC operations with DARC [1] (refer to Figure 3 for this discussion). The Host recovery mechanism (i.e., automatic switchover to the backup Host computer) is attempted, and, if susccessful, ATC operations can continue with Host. If this and other, manual attempts to revive the Host fail, facility personnel will switch the Host out of the active configuration and make the 9020 CCC the active system. This will require a relatively lengthy startup since the 9020 CCC is in a dormant state and receives no flight and radar data inputs while Host is active. No data generated by Host will be used by the 9020 CCC during startup. Because the fallback mechanism is only required for a short stabilization period (estimated at three months for the first site and considerably less for the other sites) and because problem elimination through extensive Host testing is expected to make switchover to the 9020 CCC a rare event, a more rapid, warm start of the 9020 CCC is not required.

2.2.3 Facility Considerations

A computer room with proper environmental conditions will be required at each ARTCC for the Host computer. The location of the Host has been selected on the basis of an overall plan for ARTCC space utilization during the transition and the final operational implementation of an ACF. A wiring extension will be constructed to expand the current control room (first and second floor) and to house (in the basement) the computer systems that will ultimately be in an ACF (see Figure 5).

Installation of Host computers at ARTCCs will begin after (a) the extended wing construction and computer room site preparation are finished and (b) extensive FAA Host tests are completed at FAATC. These tests will include demonstration of Host installation and 9020 System to Host switchover as it will be done at a field site. Host installation at field sites will begin in early 1986. Operational readiness demonstration (ORD) at the last site is currently planned in mid 1987 (see the schedule, Figure 6). Several installation and checkout teams will be required to achieve this Host implementation schedule. The Host prime contractor will be responsible for installation checkout, and testing of the equipment. FAA will accept the system upon contractor demonstration of full system operation with the contractor modified 9020 software.

Three Host systems will be delivered by the Host prime contractor in addition to the 20 systems for CONUS ARTCCs.[2] One of these, the

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1/ Note that a controller has the ability to switch his/her radar presentation (from Host or 9020) to DARC at his own discretion.

2/ An optional, 24th, system may be procured for training use at the FAA Academy. If procured, this system will be one of the first to be delivered.

first system to be delivered, goes to FAATC for production phase testing. This system will become the Host System Support Facility at FAATC after testing is completed. The other two systems will be provided, as Government Furnished Property, to the two AAS contractors in early 1985.

2.2.4 Operational/Training Impact

The operational impact of Host transition on the air traffic controller will be minimal. The control position equipment (PVD, flight strip printer etc.) is not affected and the application software modifications that were made should be transparent to the controller. Some controller instruction will be required to familiarize the controller with the failure mechanism for the initial Host stabilization period.

The introduction of new equipment, new support software, a new control program, and some application software changes will have an impact on operations and maintenence personnel. Training of computer operators, hardware maintenance technicians, and software specialists will be required.

2.2.5 Program Considerations

Three important program considerations drive the Host program. First, because the Host System will alleviate the serious en route capacity concerns for the mid-to-late 1980's, the Host program has been structured to minimize technical and schedule risk. This consideration is manifested in the particular selection of the Host interfaces to the existing en route system and in the determination of the acquisiton approach. It also gave rise to the requirement for minimizing changes to the complex 9020 software during the rehosting process.

The second consideration is the necessity for ATC system stability during subsequent transition steps. Once installed at an ARTCC, the Host computer should remain in place at least until the ACCC has become stable at that facility. This implies that a Host should not be relocated within the facility and that the Host should not be replaced or upgraded to a different model computer. For this reason, the Host will have sufficient capacity to execute 9020 software under a virtual machine operating system for a 1995 scenario at the largest en route center.

Third, the desire for an unconstrained total AAS design that can meet long term ATC needs in a cost effective manner has had an impact on the overall transition strategy. In particular, the Host computer specification was in no way based on AAS functional and performance requirements. This, together with the AAS design evaluation criteria, will ensure that the existence of Host will not bias the AAS design and that the consideration of Host for use in the ultimate ACCC will be based strictly on life cycle cost considerations. While the 9020 software will have to be modified to operate with the ISSS flight data presentation and manipulation system, FAA experience with an early experimental version of such a system (Electronic Tabular Display System - ETABS) demonstrated the feasibility of the necessary modifications. FAA analysis predicts that capacity impact of software modifications on Host would be negligible. Finally, to facilitate the introduction of ISSS and AAS transistion and the fallback mechanisms for those systems, a virtual machine control program was specified for Host.

2.3 ISSS Transition

The Initial Sector Suite System (ISSS) transition is the second step (Step 1/2) in the deployment of the ACCC. The ISSS introduces the new AAS man/machine interface to the ARTCC and enables productivity improvements in the support for ATC services.

2.3.1 System Definition

The ISSS introduces the new sector suite with its display and input devices and new methods for the controller and automation system to communicate (i.e., a new man/machine "language"). Physically, the sector suite will meet the ultimate AAS requirements and therefore, will not require modification in later transition steps, with the possible exception of changes to some interim interfaces that are required to operate with the ARTCC equipment in the Host system configuration. The sector suite will consist of one to four identical (common) consoles each of which will have a VSCS panel. Each console will contain one or more embedded microprocessors for display refresh and handling device input/output. At least one of the consoles of a sector suite will have an interface to DARC, designed so that this console will be able to provide the controller with a radar presentation if the radar data processing portion of the ISSS fails. This interface will be required through the next transition step, until the ACCC becomes stable.

2.3.1.1 System Configuration

The ISSS will consist of an AAS design-dependent combination of Host system elements, ACCC system elements, and the interim software and hardware required to tie the Host and ACCC elements together into an operational system. In addition to the sector suite, it will contain a small subset of the ACCC computer hardware and software, the Host computer and 9020 software, and the subset of the ACCC Local Communications Network (LCN) necessary to support communications among these elements. Finally, a (design dependent) mechanism to provide the switching between ISSS and Host System (with PVDs and flight strip printers) is required. This mechanism will be removed together with the old control room equipment (PVDs, flight strip printers, etc.) and any other equipment (e.g., portions of the display channel) the AAS prime contractor chooses to replace with new ISSS equipment.

At this transition step the bulk of the ATC data processing is still being performed by the 9020 software in the Host system. New (ACCC) software will be required for the new man/machine interface (language), particularly flight data display and manipulation. Modifications to the 9020 software will be needed to provide the appropriate data base interface to the new flight data display and manipulation software.

2.3.1.2 Representative ISSS Architecture

Figures 6 and 7 present one of many possible ISSS architectures. They illustrate that the AAS prime contractor has the freedom to distribute some processing to an application computer systems dedicated to each sector suite, to possible new "central" processor(s), or, for that matter, to the Host. The "distributed sector suite processing block" over two of the common consoles but not over the radar ("R") console

illustrates: (a) the requirement for a relatively independent means to preserve flight data information when the ISSS fails - a replacement for the current manual capability to mark and sort (paper) flight progress strips and to pass them to controllers of adjacent sectors (no flight strips will be printed by the ISSS); and (b) the absence of a requirement to provide backup radar processing (since DARC still serves that function). An ISSS design that includes backup radar processing will be permitted so long as this feature does not adversely impact the ISSS development schedule. The "interim interfaces" are included in the Figures in recognition of the potential need in the ISSS for both hardware and software that will not be part of the ACCC.

The presence, in Figure 6, of new sector suites (bottom left of Figure 6) and old position equipment (PVDs and flight strip printers - bottom right of Figure 6) is representative of the fact that there will be two control rooms at each ARTCC from the time sector suite installation begins until the ISSS becomes sufficiently stable to permit removal of the old equipment. The ISSS configuration must permit use of the new control room for ISSS system checkout and for subsequent training of controllers in the use of the new man/machine interface while normal ATC operations with the Host System and old control room continue. After operational cutover to the ISSS, it must be possible to switch active operation between ISSS (using the new control room) and the Host system (using the old control room). The VSCS design and transition plan must accommodate this strategy for ISSS checkout, training and initial operation.

2.3.2 Backup Mechanisms

During the initial ISSS stabilization period, ISSS failure will lead to operation with DARC[1/] (refer to Figure 6 for this discussion). Both radar and non-radar controllers should, in most cases, be able to get flight data information from the normal flight data backup mechanism that is part of the ISSS design. Attempts to recover full ISSS capability will be made and, if successful, ATC operations with ISSS will resume. If it is determined that ISSS cannot be revived fairly quickly (in 10-20 minutes), facility personnel will switch the ISSS out of the active configuration and make the Host System (with the old control room) the active system. At that time, all controllers would have to move from the new to the old control room. The Host System will require a relatively lengthy startup since the Host software for this operational configuration, resident in a separate virtual machine, is in a dormant state and receives no flight and radar data inputs while the ISSS is active. As in the case of transition to Host, no data that were generated by the new system (ISSS in this case) will be used for the Host system startup. Note that each controller has the option of using DARC on the PVD during this startup period.

The second level fallback mechanism is admittedly awkward since it requires an en masse controller move from one control room to another and since the startup after the move is slow. On the other hand, this

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[1/] Note that the controller will have, as he/she did with the 9020 and later the Host System, the ability to switch his/her radar presentation from ISSS to DARC at his/her discretion.

fallback is required for only a short stabilization period (estimated at 3 months at the first site and considerably less at other sites) and problem elimination through extensive ISSS testing is expected to make switchover to the Host system an extremely rare event.

2.3.3 Facility Considerations

To carry out the transition to ISSS outlined above, a new control room, large enough to house the sector suites needed to handle all of an ARTCC's sectors (plus spares), must be available. Since the existing ARTCC building does not have sufficient space for a new control room, an extension must be added to the wing that houses the current control room (see Figure 5). As indicated in section 2.2.3, this wing extension will be constructed early enough to house, in the basement, the Host computers.

2.3.3.1 Rationale for New Control Room

The decision to add to the wing is justified on several grounds:

(1) ISSS transition is significantly simplified with this approach. If a new contol room is not available, an incremental installation of sector suites must be used (i.e., installing some new suites, removing some old ones, installing more new suites, etc.). This would lead to extensive disruption of the control room, an operational configuration with both old and new suites, and a much longer installation period (with the accompanying operational disruption) than a single step replacement of sector suites. Furthermore, the approach does not provide the security of having the former control room for fallback purposes during some of the installation steps. A cost analysis has shown the cost of transition with a wing addition to be only slightly higher than the cost of an incremental transition.

(2) The building expansion provides sufficient additional space to make an ARTCC into an ACF. In addition to the ACCC, a number of other new computer systems will be brought into the ACF as part of the NAS Plan. The basement of the wing extension is the only place where one could realistically have a large enough computer room for many of these systems. Also, as terminal sectors are incorporated into the ACCC, the number of sectors in many ACFs will be larger than that which the existing control room can house. It is planned to use the space vacated by removal of the PVDs, flight strip printers, etc. for the terminal control positions.

2.3.3.2 ISSS Facility Development and Installation

To carry out the transition to ISSS with minimal disruption to ATC operations, a carefully staged facility plan, that includes the following steps, is needed:

(1) Construct the wing extension.

(2) Put a wall between areas B and C of Figure 5. The control positions are currently located in area C. This is the area that has been called the "old control room".

(3) Move the equipment in area B to other parts of the facility. This equipment, in most of today's facilities, includes the controller training lab (DYSIM), the system maintenance and monitor console (SMMC), teletypes that receive flight, weather and other data, and the E-desk complex (watch supervisor, flow control position, military coordinator, and center weather position).

(4) Make areas A and B into a single room, appropriately reconditioned for a new sector suite installation.

(5) Remove the old radar brite display equipment (RBDE) from the basement to provide additional computer room space for ISSS and VSCS elements.

(6) Install the ISSS equipment including any new computers, the LCN, and sector suites. All LCN cabling installation necessary for ACCC operation in the new control room must be done at this time to reduce operational disruption during ACCC transition.

Installation of ISSS at ARTCCs will begin at the start of 1989, after extensive controller evaluation of the new man/machine interface, full functional tests and stress tests of the ISSS at the FAATC. ORD of the first ARTCC will be in early 1990, following a six month installation and checkout period, and nine months of controller training and tests. ORD at the last ARTCC is scheduled for early 1991. The AAS prime contractor will be responsible for installation of the equipment. FAA will accept the ISSS hardware and software upon contractor demonstration of the full system in an operational environment.

2.3.4 Operational/Training Impact

The introduction of ISSS will have a significant impact on both the controllers and the hardware/software maintenance personnel. The ISSS, with its new sector suite and man/machine "language," is where the major AAS changes are introduced to the controllers. Indeed, the goal is to limit to this transition step the changes that the controller will see. When the ACCC is implemented, the controller should be thoroughly familiar with ATC operations using the new sector suite and in that way, problems with the ACCC hardware or software will not be masked by controllers' unfamiliarity with the man/machine interface. While new hardware and software will be introduced with the ISSS, the impact will be far less than that of the major software and hardware replacement that accompanies the ACCC.

Extensive instructor and controller training in the use of the new sector suite and the man/machine language will be required before ATC operations can be switched from the Host System to the ISSS. This training will include initial classroom and/or computer based instruction followed by extended work with the ISSS equipment in simulation mode. Nearly one year has been scheduled for controller familiarization and training at each facility prior to ORD.

This training cannot interfere with ongoing ATC operations with the Host system. To permit training of the entire ARTCC controller population, a significant amount of overtime will be required. Since the Host System and the ISSS share a significant amount of equipment (particularly the Host computer), care must be taken in ISSS design that full ISSS training and ATC operations with the Host system can go on simultaneously without operational impact.

Technical training will be required for the ISSS maintenance workforce in the areas of sector suite consoles, LCNs, new processors introduced with ISSS, and all interim hardware (particularly interfaces). Software maintenance training will be required for all new software and software modifications that are part of the ISSS. This includes display software, LCN software, electronic flight data software, interim/interface software, adaptation software, and support software. Since software maintenance will be, to a large extent, centralized at the FAATC, there will not be a requirement for extensive software training at ARTCCs. The AAS prime contractor will be responsible for developing the necessary hardware and software training programs during the acquisition phase of the AAS procurement.

2.3.5 Program Considerations

The major objectives of this transition step were to introduce a significant element of the AAS early, before the full set of ACCC software can be completed, and to limit, as soon as possible, the need for controller staffing increases.

Breaking the transition from the Host system to the ACCC into two steps should reduce overall program risk and facilitate what has been judged by many to be the most difficult aspect of the Advanced Automation Program -- the in service transition to a totally redesigned system.

These objectives must be accomplished without compromise of the AAS system design and without the need for extensive interim hardware and software as part of the ISSS. As many of the new ISSS elements as possible should become, with little or no modification, part of ACCC. The policies and program decisions that support this are:

(1) The sector suite console (hardware) developed for ISSS will meet all ACCC sector suite requirements.

(2) Emphasis will be placed on the design of the total Advanced Automation System itself. Separate development of ISSS elements (except for the sector suite console) will not begin until after Critical Design Review of the AAS.

(3) ISSS scope decisions (i.e., the extent to which Host system elements will be replaced by ISSS) will be based on tradeoffs between schedule impact and interim hardware/software needs.

(4) ISSS schedule risk will be reduced by limiting the sector suite console to components (particularly the display head) that require little or no technology development.

(5) The scope of ISSS was chosen to clearly separate the impact areas of ISSS and ACCC. As indicated in section 2.3.4, the ISSS has a major impact on the way the controller interacts with the ATC automation system and the ACCC has a major impact on how the new hardware and new software carry out the basic ATC functions.

The selection of ISSS as a transition step to the ACCC has introduced one risk element. The standard approach of designing a system, fully testing a prototype, and then starting production has been modified to permit the early introduction of the ISSS. In particular, the production decision for sector suite consoles will be based on limited tests with demonstration software. Full tests of the ISSS at FAATC will be conducted in parallel with the sector suite console production startup (1987-1989, see Figure 6). This strategy is based on the firm belief that the major area of uncertainty is in the man/machine language, a software function, and that the refinement of this language that comes with full ISSS test will not require sector suite console redesign.

Three elements of the AAP are intended to limit the risk of this approach and to ensure that the ISSS is fully suitable for operational ATC use when installed. These are:

(1) Preparation of comprehensive set of specifications of sector suite console and man/machine interface (language) requirements prior to award of AAS contracts;

(2) Periodic formal review and participation by a representative cross section of controllers and other Air Traffic Service representatives throughout the Advanced Automation Program; and

(3) Extensive controller tests of the ISSS system at the FAATC and at ARTCCs prior to ORD.

2.4 ACCC Transition

The Area Control Computer Complex (ACCC) transition is the last step (Step 2/3) in the transition from the 9020 System to the newly design, modern automation system at the 20 CONUS ARTCCs. The Area Control Computer Complex represents one of the major elements of the NAS Plan. While it does not, when initially deployed, represent a significant advance in ATC operations, it does, by virtue of its new system design, provide the basis for future ATC system evolution.

2.4.1 System Definition

2.4.1.1 System Configuration

The ACCC will replace the remaining elements of today's en route system at the 20 ARTCCs. The computer hardware and software elements, the full LCN, and the interfaces to other ATC system elements that make up the AAS prime contractor's design will be implemented. The ACCC will include all emergency mode elements specified in the AAS specification and a facility

backup mechanism that will allow adjacent ACFs to take over the airspace of an ACF that experiences a catastrophic failure.1/

The particular ISSS elements that will be replaced in this step include the 9020 software, the Peripheral Adapter Modules (PAMs), the Display Channel (if not replaced in the previous transition step), and the DARC system. The Host computers, which will be required during the initial stabilization, will be replaced according to the contractor's system life cycle plan, at such time as it is economically desirable.

2.4.2.2 Representative ACCC Architecture

Figures 8 and 9 present a possible ISSS/ACCC transition configuration (step 2/3) and one of many possible final ACCC configurations. The shaded local communications network is representative of the FAA requirements to provide future growth and evolution capability and to permit replacement of individual processors (or processing subsystems) through use of one or more local networks based on standard interface protocols. Data Inputs from external data sources could come into their network directly (as shown in Figures 8 and 9) or could come directly into some of the ACCC processors. The Host and processor blocks in the upper half of the diagrams are representative of the fact that the ATC processing will be done by more than one, possibly many, processors, quite likely supported by processing subsystems (in the lower half of the diagram) associated with one or more individual sector suites. The AAS design will determine the number of these and the functional allocations to processors. The peripherals, control units, and connections to processors at the top of the diagrams are indicative of the likely need for peripheral support, some shared, by several of the ACCC processors. The change from "Host" in Figure 8 to "Processor" in Figure 9 is representative of the requirement for a system architecture that allows processor upgrade/replacement as dictated by cost or capacity considerations throughout the life of the ACCC. Figure 8, based on the ISSS architecture postulated in Figure 7, shows that the initial transition system permits operation in an ACCC configuration, in an ISSS configuration, and with DARC. Note that the LCN is expected to eliminate the need for physical switches to switch from one of these configurations to another.

Figure 10 presents another conceptual view of the ACCC. It connotes the generalized distributed ACCC architecture built around a Local Communication Network (LCN). Individual ACCC processors or processor subsystems are tied to the LCN via bus interface units, and external data sources are connected via gateways. The "interfacility data" connection represents the requirement for communication between ACFs, between ACF and ATCT, and with other (FAA, military or foreign) ATC facilities. The LCN connections to MPS, FSDPS, and CWP on the left side of Figure 10 indicate that the LCN will be required to tie these to the ACCC and to one another.

1/ Facility backup will impose new interfacility voice and data communications requirements. These must be factored into the FAA's overall communication system planning.

2.4.2 Backup Mechanism

During the initial ACCC stabilization period, ACCC failure will lead to operation with DARC and the backup flight data presentation that was introduced with ISSS. Figure 8 is indicative of the requirement that the radar display of the sector suite must still be connected to DARC. Attempts to recover the full ACCC capability will be made and, if successful, ATC operation with ACCC will resume. If it is determined that ACCC cannot be revived fairly quickly (in 10-20 minutes), operations personnel will switch the new ACCC elements (hardware and software) out of the active configuration and make the ISSS the active configuration. In Figure 8 this includes Host with 9020 software, the interim interfaces as well as the Display Channel (assumed, as it was in section 2.3, to be part of ISSS for illustrative purposes). The virtual machine operating system in the Host will permit the 9020 software required for fallback to ISSS to start up from dormancy in a separate virtual machine in one of the Host processors. The ISSS and ACCC system designs will determine the precise mechanism and duration of ISSS startup after switchover from ACCC. The constraints placed on the AAS contractor in developing this mechanism will be that no data generated by new ACCC elements be used for ISSS startup. As in the case of transition steps 0/1 and 1/2, a rapid startup is not required because the mechanism will only be used for a short period, and then, because of extensive prior testing, only rarely.

2.4.3 Facility Considerations

Transition to the ACCC will require installation activity in the computer room, in the ISSS control room, and in the old control room vacated by the removal of PVDs, etc. New ACCC hardware (processors and possible new LCN elements) will be installed in the computer room. This will require some site preparation and installation of new hardware, but, because of the LCN technology, will not interrupt ongoing ISSS system operation.

Control room installation impact will be minimal. The LCN elements, installed with ISSS, were designed for full ACCC use and therefore no cabling work is needed. Some distributed ATC processor system upgrades may be required, but, the LCN design is required to permit additions of new elements to the network without operational interruption. If this equipment is packaged in the sector suite, instead of the computer room, the upgrades can be done on a sector suite by sector suite basis and will not cause any more interruption than routine sector suite maintenance. After the old control has been refurbished, LCN and new sector suites will be installed in the "old" control room in preparation of the operational incorporation of terminal sectors into ACCC. This will be done around the time of ACCC transition, but, because it can be done in a sterile environment in a separate control room, ongoing ISSS and ACCC operations will suffer little disruption.

Once the ACCC has become operationally stable, the last elements of the current NAS system and any interim interfaces can be removed. Some interim interfaces will have to be removed from the sector suite consoles, but again, this can be done as part of the routine maintanance process (extracting cards and unplugging cables) and should not degrade system operation. The most disruptive removal in the control room will involve the now unnecessary cables between DARC and the sector suites. All other elements to be removed are outside the control room, either in

the new computer room or in other parts of the ARTCC building. They can be electrically isolated from the ACCC and therefore removal will not affect ATC operations.

Installation of ACCC at the 23 ACFs will begin in mid 1990, after complete functional and stress tests at FAATC (see Figure 6). ORD of the first site is scheduled for 1992 and the last site in late 1993. The AAS prime contractor will be responsible for installation of the equipment. FAA will accept ACCC hardware and software upon contractor demonstration of the full system in an en route operational environment.

2.4.4 Operational/Training Impact

The impact of ACCC introduction on the Air Traffic Controller will, as discussed previously, be minor since there will be few changes to the sector suite input/output devices or to the man/machine interaction language. Problems with the new software and hardware will be readily identified as such since the controller is by now thoroughly familiar with the use of the new sector suite. ACCC will contain the new functional capabilities of AERA-1 but these will not be made available to the controller until after ACCC is stable. Controller training requirements for this transition, therefore, are limited to the familiarization with the initial transition fallback mechanism, ACCC failure recovery characteristics, and any new functional capabilities.

The major operational impact of ACCC transition will be on hardware and software operations and maintenance personnel. Training in ACCC system operations, new hardware maintenance, and software maintenance will be required. As in the case of ISSS, software maintenance will be centralized at the FAATC and therefore there will not be a requirement for extensive software training at ARTCCs. The prime contractor will be responsible for developing the necessary hardware and software training programs.

2.4.5 Program Considerations

The major objective in this transition step is to complete the ACCC installation by bringing in the bulk of the newly designed ATC hardware and software. This must be done with minimal disruption on the Air Traffic Control process, both during installation and during the system stabilization process. Because of the criticality of the ATC application and because of the difficulties encountered in the introduction or transition of other large software systems, several measures will be taken to achieve this objective:

(1) The AAS development program will be conducted to ensure the maturity of the software at the time of ACCC ORD. A top down, structured design and development approach, based on the best software engineering principles, will be adopted. This will be supplemented by extensive performance modeling, throughout the design and development process, of the ISSS, the ACCC and projected future ACCC enhancements. Extensive functional and stress tests will be carried out, first at the FAATC and later at the field sites (see Figure 6). Finally, to assure compliance with requirements, the program will include an extensive Independent Verification and Validation (IV&V) activity.

(2) The transition to the ACCC will be transparent to the controllers. This is accomplished by introducing the new man/machine interface at an earlier transition step and allowing sufficient time between the steps to let controllers become thoroughly familiar with this new interface.

(3) New functional capabilities, such as AERA-1, that are part of the ACCC will not be activated until operational stability of the ACCC is achieved.

(4) Initial operational use of the ACCC will be limited to the same airspace and sectorization that was in use at the ARTCC with the ISSS. The transition to the full ACF concept, with its realignment of en route airspace and consolidation of terminal sectors into the ACCC will not begin until the ACCC operation is stable.

2.5 Operational Transition to ACFs

The last three sections have discussed the transition from the 9020 based en route system at the 20 CONUS ARTCCs to an Area Control Computer Complex (ACCC) at an Area Control Facility. During the period when the ISSS is upgraded to an ACCC at these facilities, the three ACFs at Anchorage, Honolulu, and at the New York TRACON will also receive an ACCC. During the period when ISSS serves as the primary ATC automation system at the ARTCCs, the additional sector suites required for fully integrated en route/terminal control will be installed at the 20 ARTCCs. These two steps complete the AAS equipment installation at an ACF necessary to carry out the operational transition to the ACF airspace/control concept.

2.5.1 Completion of the AAS Installation at ACFs

The transition to the ACCC at Anchorage, Honolulu and the New York TRACON will be accomplished in a single step with equipment installed in a sterile environment. It is not expected that the ACCC, when installed, will be connected to any elements of the old automation system at the three sites. There will be enough sector suites installed to support the final ACF configuration at each of these three sites.

At the 20 CONUS ARTCCs, enough sector suites to support the ARTCCs (en route) sectors were installed as part of the ISSS. Since the final number of sectors at some of these 20 ACFs will be (significantly) larger than the number of en route sectors in the earlier ARTCC environment, new sector suites must be added to the ACCC to support the full ACF concept. The old control room (where the PVDs were located) will, as described in Section 2.4.3, receive the additional sector suites needed for ACF operation.

To avoid disruption of ATC operations, it is currently planned to complete the entire installation at a facility before any of the new sector suites are activated for operations. There is sufficient time between ISSS ORD (when operation switches from the old to the new control room) and ACCC ORD (the earliest that ACF transition could begin) to carry out this installation. Therefore, unless there is a significant delay in removal of the PVDs and flight strip printers, this requirement will not constrain the operational transition to ACFs.

2.5.2 Approach to Operational Transition and its Impact

After the above steps are completed, the ACCC will have the capacity and functional capability to support a fully integrated en route/terminal ACF airspace configuration at all 23 ACFs.

The operational transition from a system with 20, by then stable, ACCCs performing en route operations, three new ACCCs that initially have no airspace allocated to them, and the many ARTS systems and offshore centers to a system where the ACCCs at 23 ACFs are used for radar control of all airspace will be carried out gradually, over a period of five or more years. En route sectors will be realigned and, where necessary, airspace operations reassigned to a different facility. Terminal sectors can be gradually brought into the ACCC - probably an airport at a time. When the radar control for an airport is incorporated into an ACCC, a TCCC will be simultaneously established at the corresponding Air Traffic Control Tower (ATCT). This transition will present both operational and communications complexities for which extensive detailed planning will be required.

As in the case of the three steps of the en route transition, continuity of service is of the utmost importance. To provide this continuity, it is likely that for some initial period both the old terminal (ARTS) radar positions and the new positions in the ACCC control room will be manned to provide a fallback to the old system should the new system fail. In many cases, the old terminal radar positions being replaced will not be located in the ACF where the new positions will be. This means that control teams would be needed at both the ACF and at the old terminal facility. Therefore, if such a fallback scheme is selected to support continuity of operation, extensive controller overtime is expected. This approach would also require old and new tower control position equipment to coexist for a limited period in a tower cab. Because tower cab space is at a premium, this requires careful planning and, in some instances temporary towers may have to be used.

The operational impact of the transition to the full ACF concept will be felt by the en route controllers at the ACCC as well as the terminal controllers. As en route sectors are realigned and facility boundaries changed, the en route controllers will have to become familiar with the new sector geographies, new sector to sector interfaces, and new facility to facility interfaces. The operational impact of the consolidation of terminal sectors into the ACCC is significant. Just as the en route controllers had to begin using a totally new man/machine interface with ISSS introduction, the approach and departure controllers will now have to use the sector suite instead of the currently existing ARTS systems. The transition may be even more difficult since many of the controllers may, for the first time, be using an all digital radar situation display and since many of them will be moving to an ACF from an environment where they routinely work shifts in both a TRACON and a tower cab. The tower cab controllers will also be affected since they will begin to use the new TCCC position equipment at this time.

Operation and maintenance impact will be felt primarily in the tower cab since the equipment installed at ACFs will be identical to equipment already present in the facility. In the TCCC there will be new displays, computers, sensor interfaces, and software that must be maintained. As with all other AAS components, software maintenance will be centralized at FAATC.

A training program, developed by the AAS prime contractors, will be required for the terminal controllers who will be using the ACCC. This training will have to be carefully planned and integrated into the operational transition plans since the controller training must be conducted at the FAA Academy or an ACF, with the new equipment, rather than at individual TRACONs. Controllers from TRACONs must move to the FAA Academy or ACFs for this training and therefore cannot receive training during overtime hours. Overtime at the terminals will be required to support the absence of controllers attending these training courses.

3.0 SUMMARY

Transition to a totally new ATC automation system is perhaps the most difficult aspect of the Advanced Automation Program. Many programs, often involving systems smaller and less complex than the ATC automation system, have failed because transition was improperly planned and the transition steps were overly ambitious. Experience tells us that breaking the transition into a number of manageable steps greatly improves the probability of program success.

The AAS transition, besides dealing with a very large embedded system, is complicated by the fact that it is an in service transition that cannot tolerate lapses in stability and availability of service. The system to be replaced constrains possible approaches to transition by virtue of inflexible and non-standard hardware interfaces and by virtue of software that does not lend itself to partitioning and therefore step-wise replacement.

The AAS transition approach must also meet a number of broader requirements. First, capacity relief must be provided in the 1986/87 timeframe at some en route centers. Second, to limit controller staffing increases, a high priority has been placed on early controller productivity gains. Finally the AAS, as an integrated part of the NAS Plan, must support the ambitious transition from today's terminal/en route environment to a consolidated system with 23 Area Control Facilities.

The transition approach that has been presented here, consisting of a three-step transition to an Area Control Computer Complex at the 20 ARTCCs followed by an operational transition to ACFs at 23 sites, is the result of extensive analysis and planning. It meets the NAS Plan objectives with minimal operational disruption and with manageable, technical, cost and schedule risk. It can be achieved without the need for extensive interim hardware and software and without compromise of a new system design for the 1990's and beyond. Proper attention to this design will allow FAA to take advantage of the potential of computer technology of the 1980's and thereby achieve a system architecture that will lead to a long system life and future system growth in an evolutionary manner.

In closing, it must be kept in mind at all times that this paper has only presented an approach to guide the transition. The ultimate success of the Advanced Automation Program will depend on extensive and careful planning for the implementation of this approach.

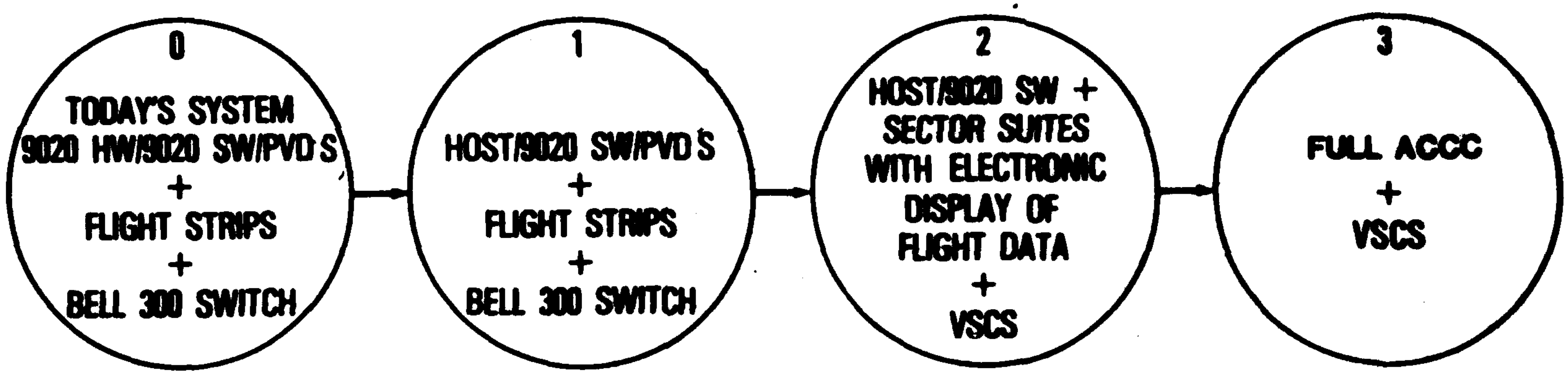


FIGURE 1. EN ROUTE SYSTEM TRANSITION STATES

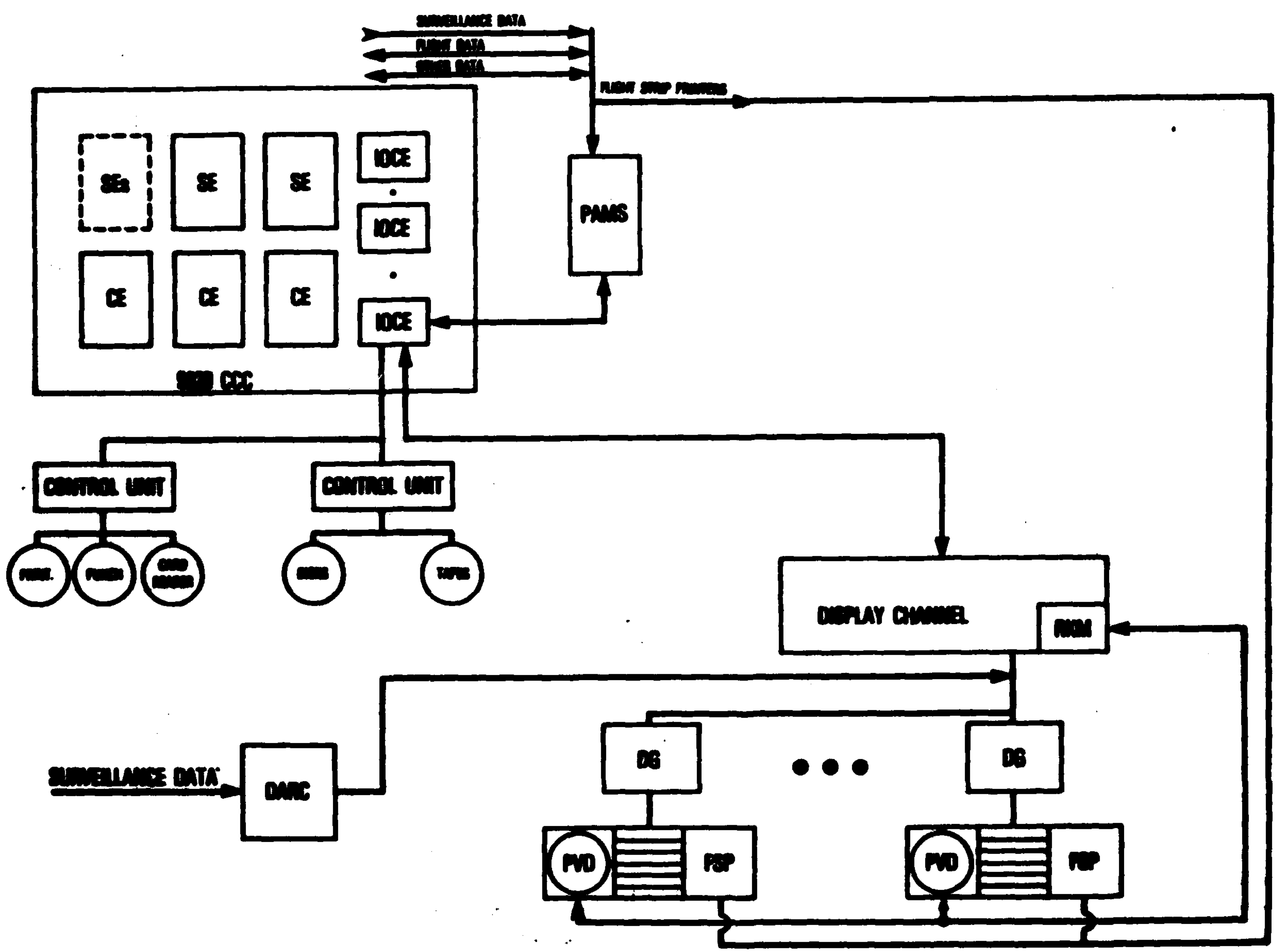


FIGURE 2: TODAY'S SYSTEM, STATE 0

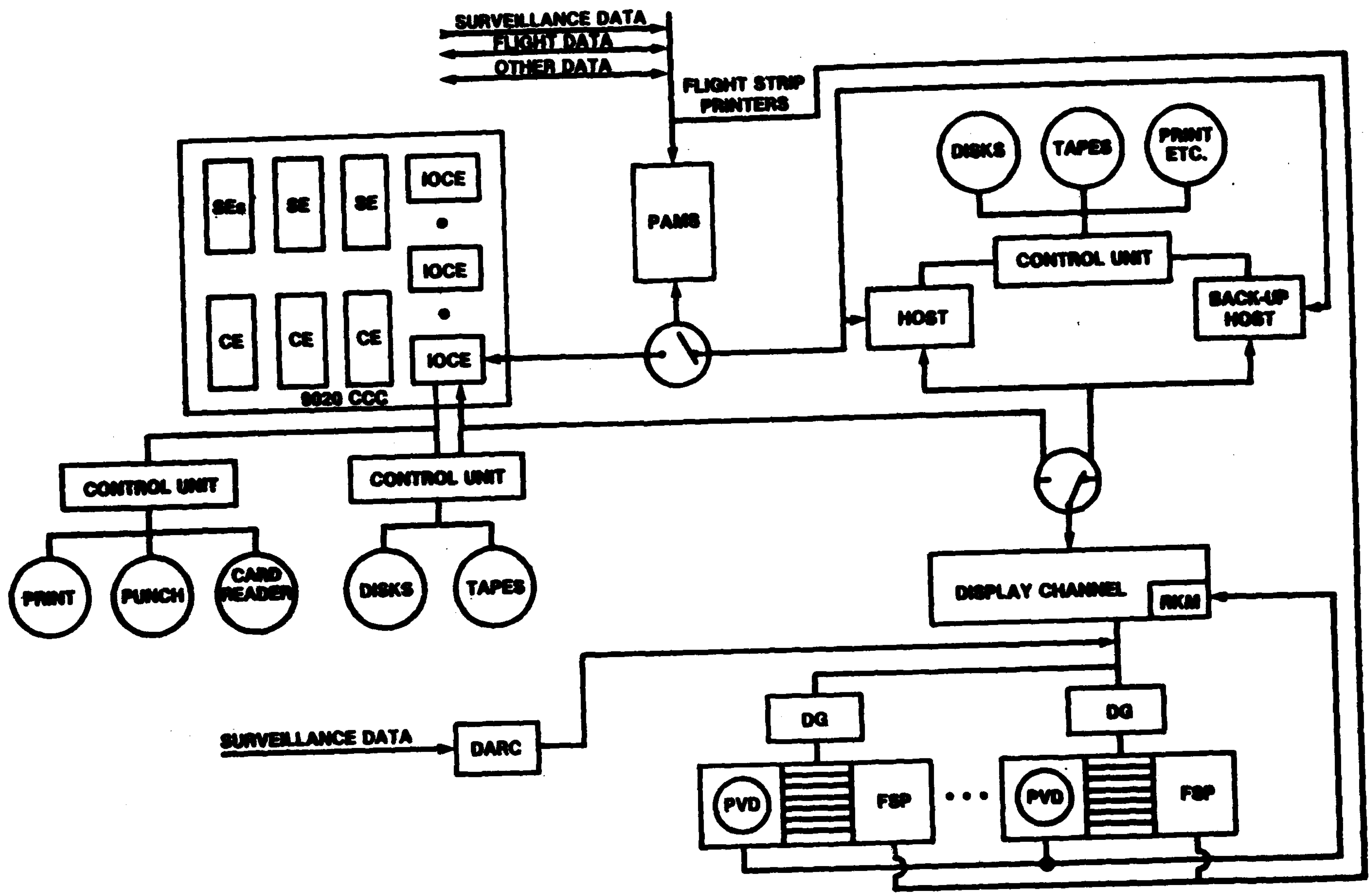


FIGURE 3: TRANSITION TO HOST, STATE 0/1

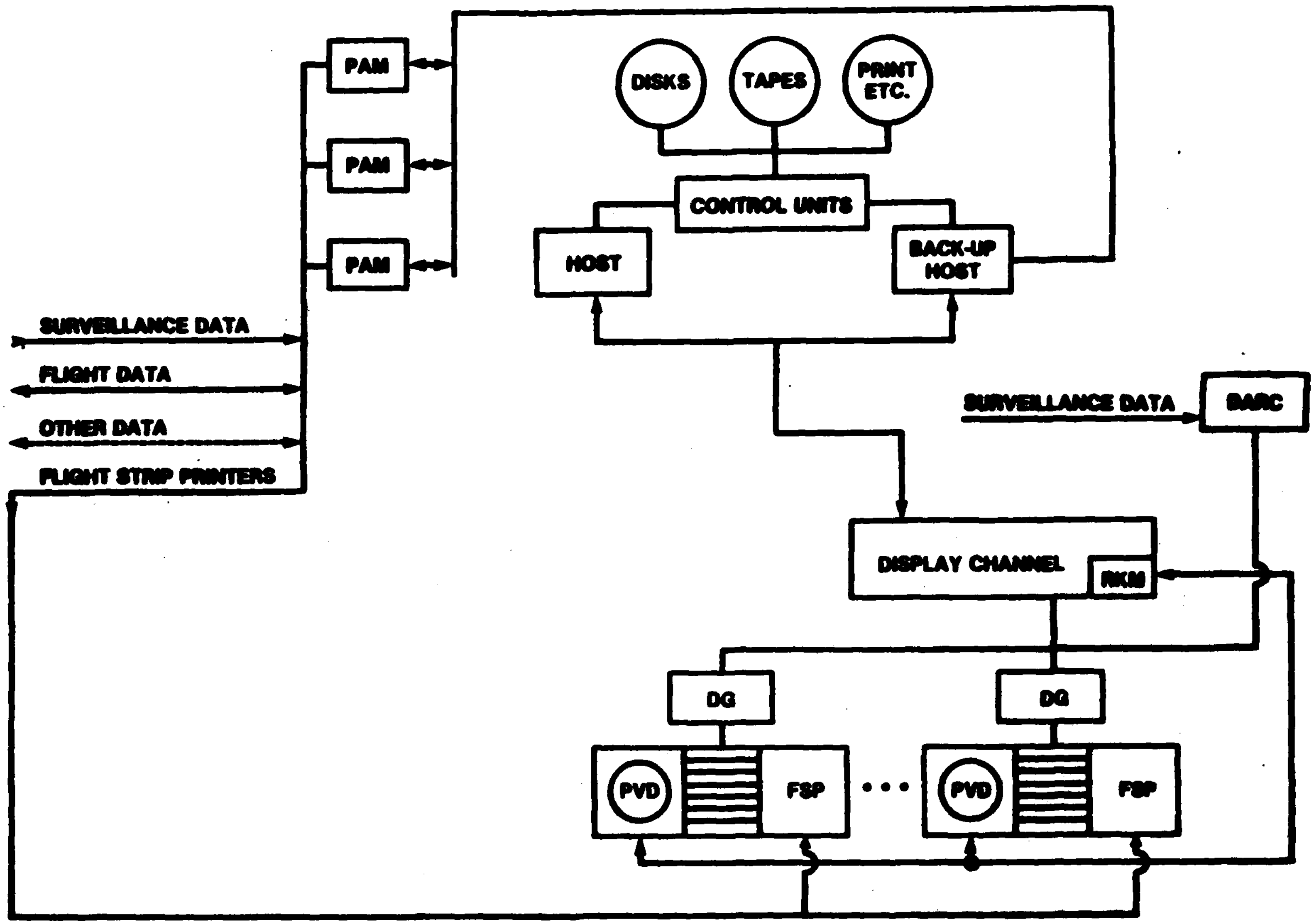


FIGURE 4: HOST AFTER REMOVING 9020, STATE 1

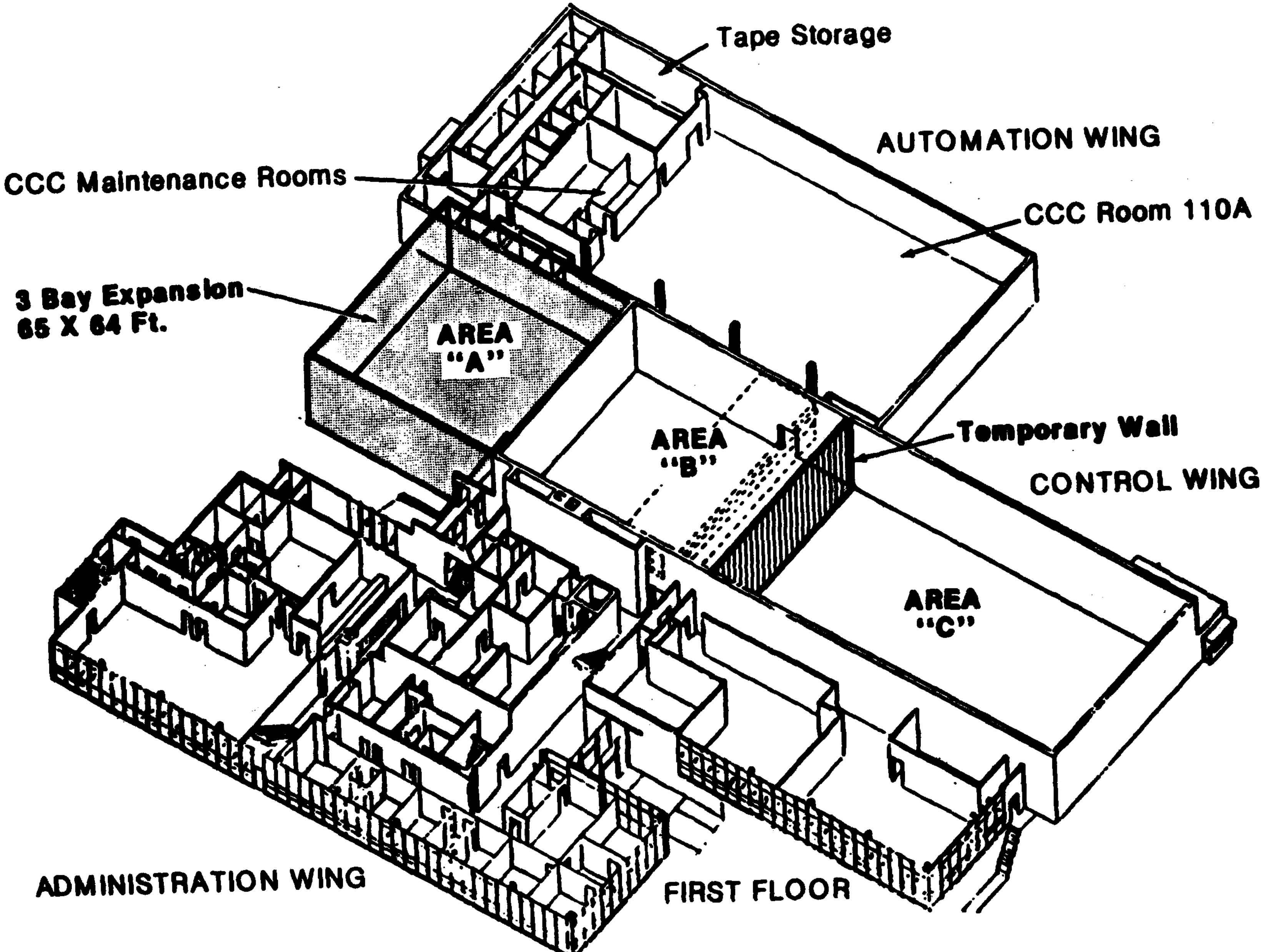


Figure 5. ARTCC Building Expansion

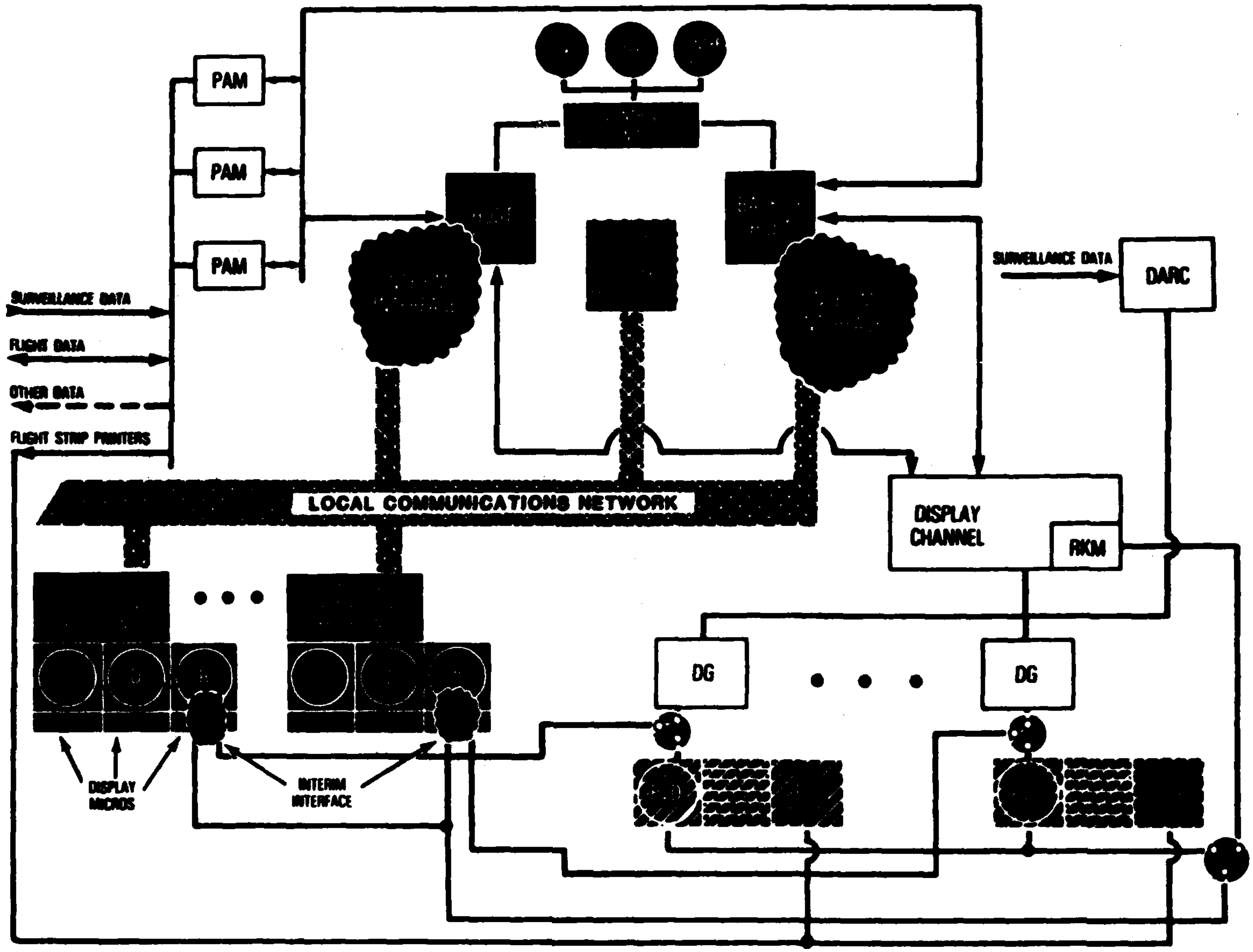


FIGURE 6: TRANSITION TO ISSS, STATE 1/2

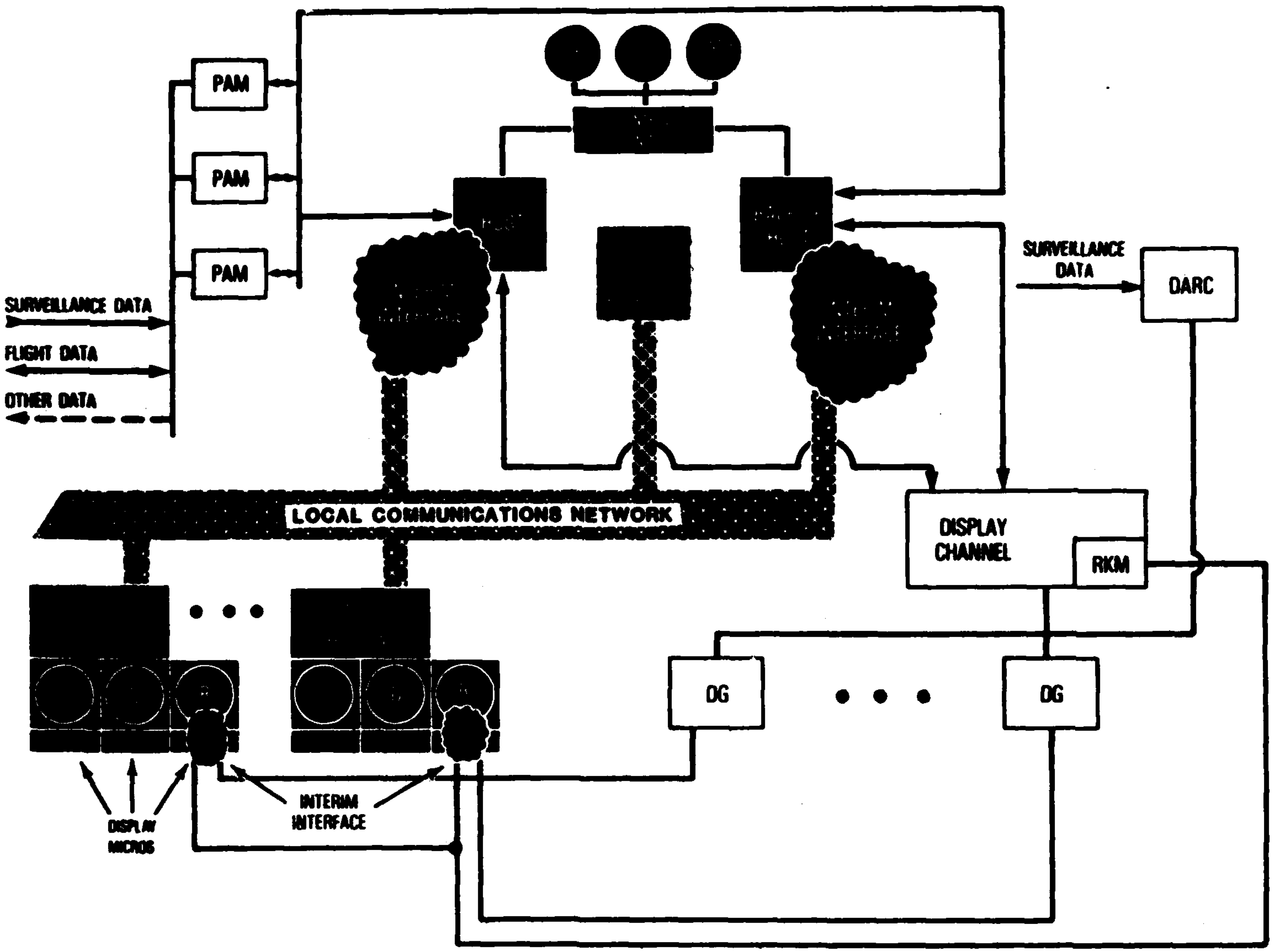


FIGURE 7: INITIAL SECTOR SUITE SYSTEM, STATE 2

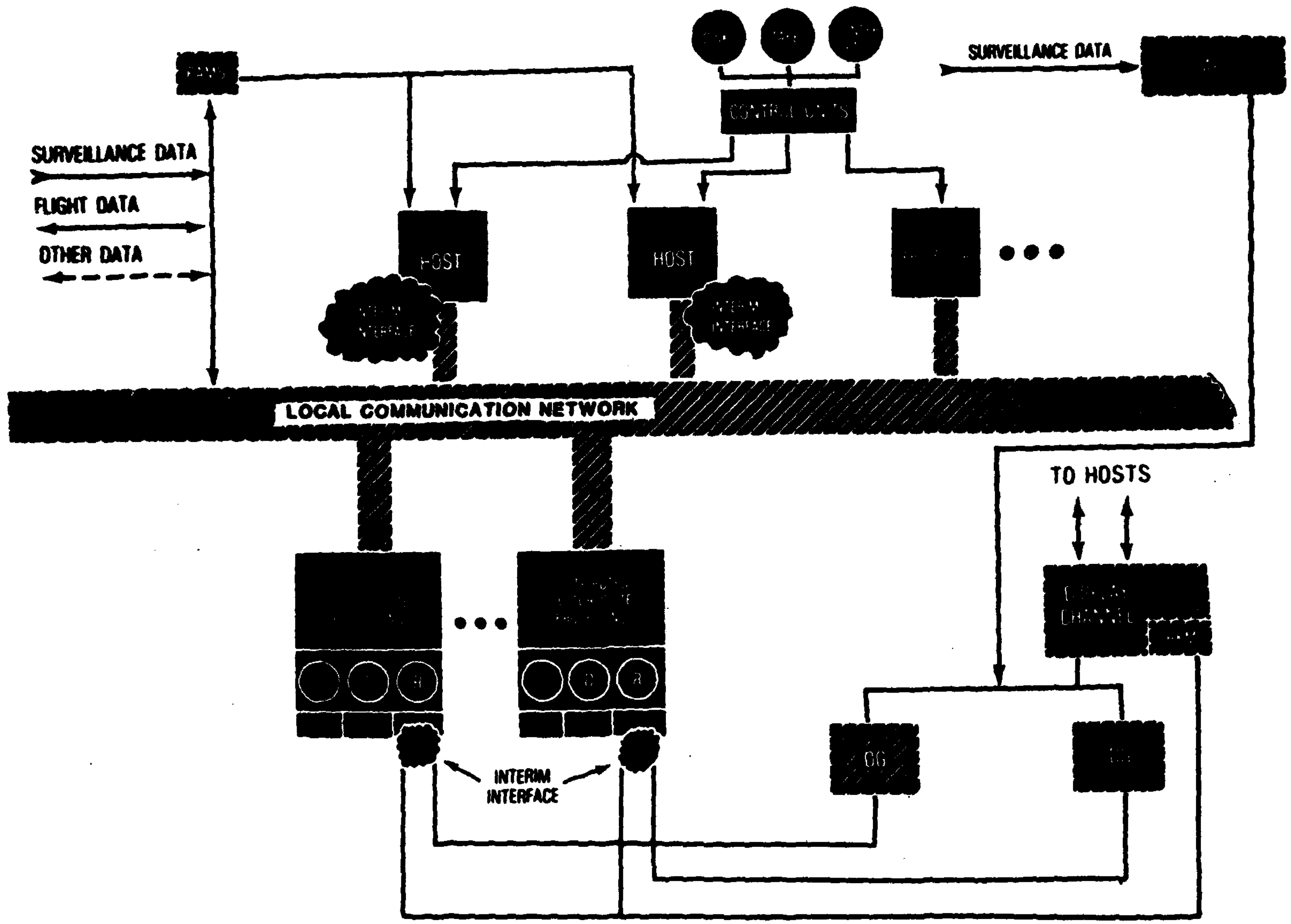


FIGURE 8: TRANSITION TO ACCC, STATE 2/3

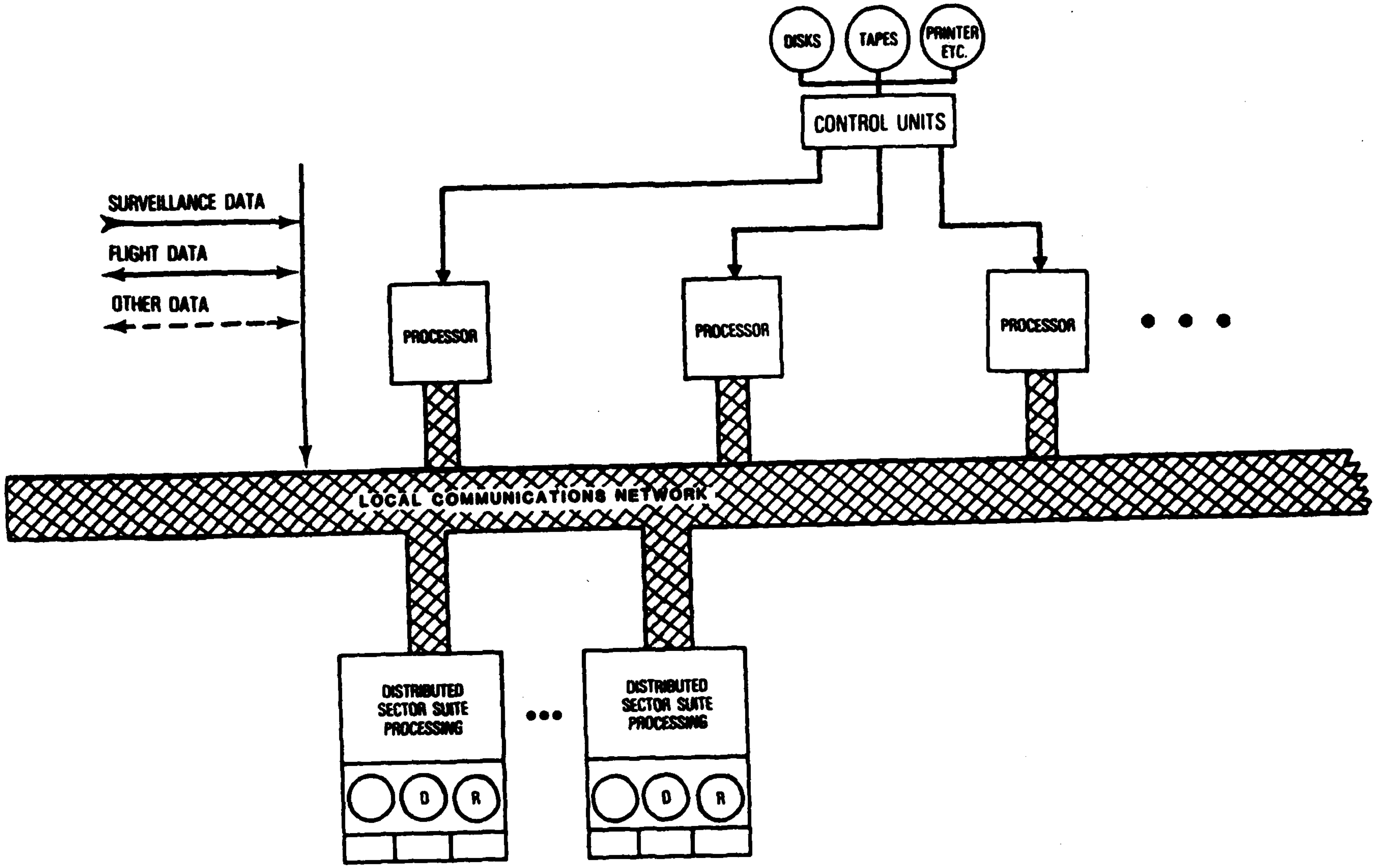
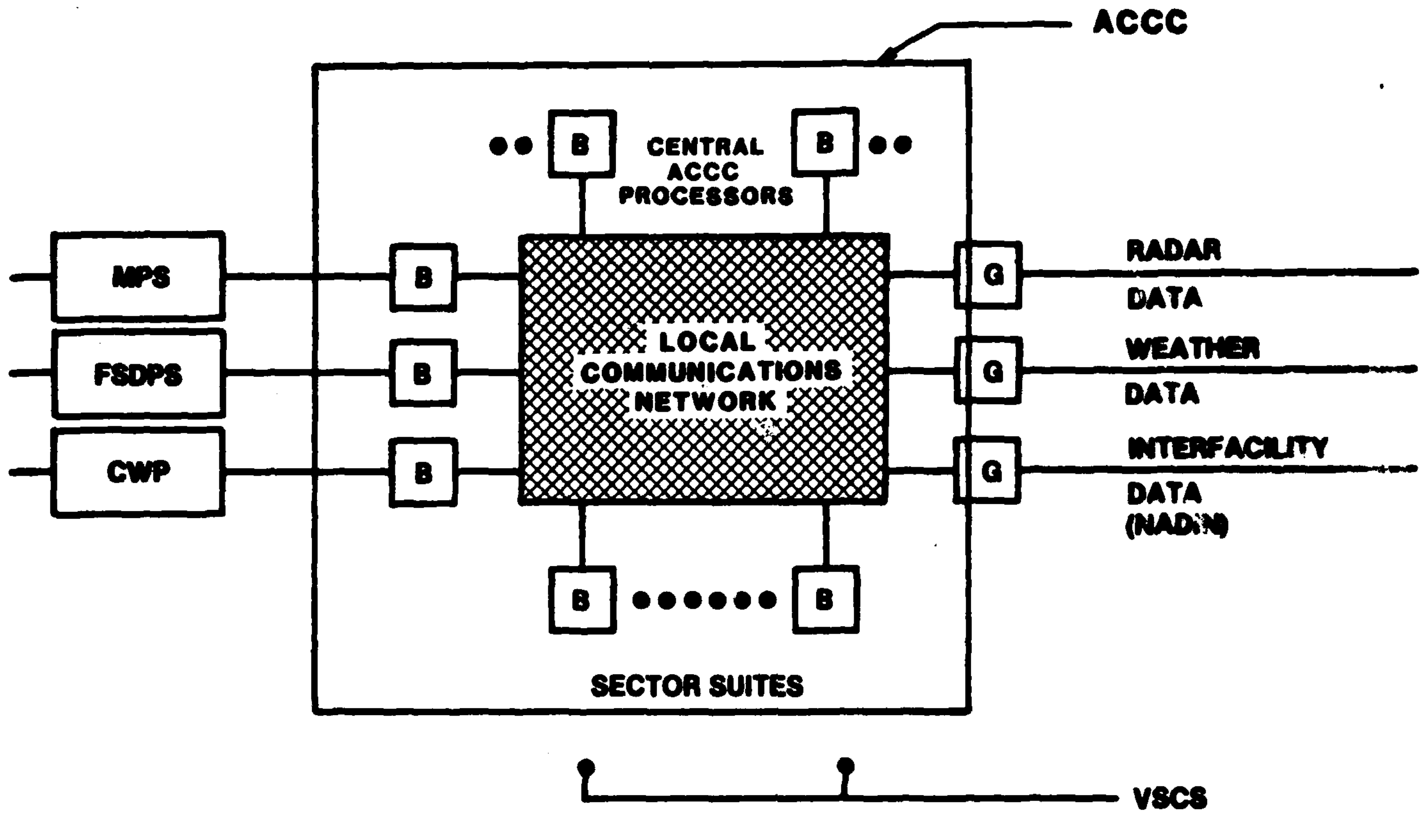


FIGURE 9. AREA CONTROL COMPUTER COMPLEX, STATE 3



MPS — MAINTENANCE PROCESSING SYSTEM
FSDPS — FLIGHT SERVICE DATA PROCESSING SYSTEM
CWP — CENTER WEATHER PROCESSOR
VSCS — VOICE SWITCHING AND CONTROL SYSTEM

G — GATEWAY
B — BUS INTERFACE UNIT

FIGURE 10. AREA CONTROL COMPUTER COMPLEX - ANOTHER VIEW

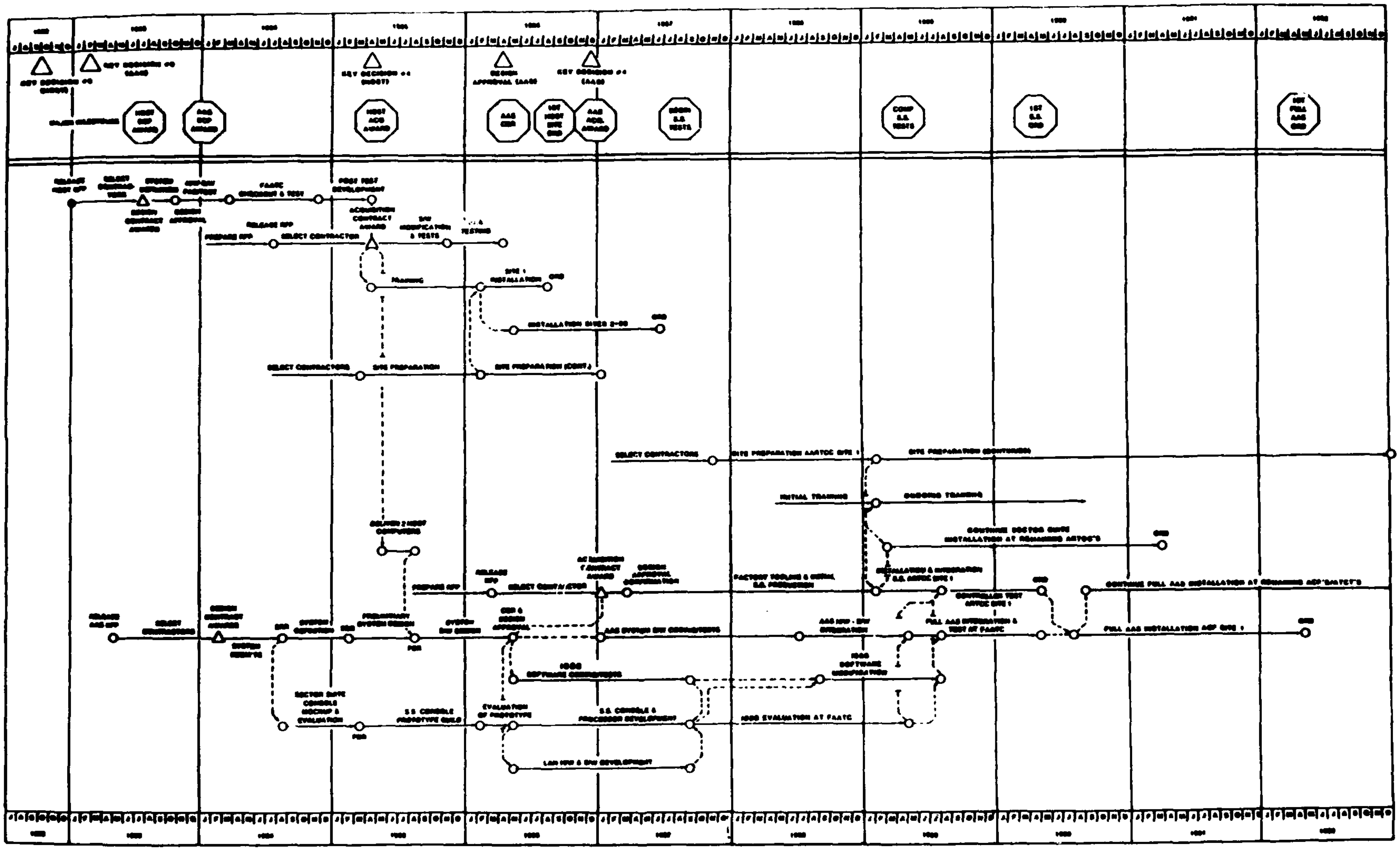


FIGURE 11. EXECUTIVE SUMMARY NETWORK.

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